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(54) Rotary seal member coated with a chromium carbide-age hardenable nickel base alloy.

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Description

Field of the Invention

5 The invention relates to fluid seals for rotary shaft applications in which at least a portion of a contact surface is coated with a chromium carbide-age hardenable nickel base alloy. A fluid seal according to the preamble of claim 1 is known from DE-A- 3 701 616. The invention relates furthermore to a process for coating a surface of a face contact seal according to claim 10.

10 Background of the Invention

Rotary contact seals are seals in which the rotating and stationary seal faces are kept in nominal contact. The seals have minimum fluid leakage but are limited in speed capability by frictional heat generation and wear problems at the interface between the faces. Rotary contact seals can be either
15 circumferential seals, with a circumferential contact area between the internal diameter of a sealing ring and the shaft surface, or face seals with contact between the radial seal faces.

Generally, the basic face contact seal consists of two solid rings of material held in nominal contact along a radial face by an axial load. Usually one of its rings is a soft material such as a carbonaceous material, i.e., carbon and the other would be a hard material such as a metal or metal alloy; i.e., steel,
20 tungsten carbide or silicon carbide. Which ring rotates and which is held stationary depends on the individual seal design and application, although it is more common for the hard ring to rotate. The rotating ring is usually mounted in a fixed position on a shaft, with the stator ring loaded so as to press axially against it. The axial load can be provided by springs, bellows, magnetic means or the like. Although contact seals have negligible leakage characteristics, they are subject to wear problems due to the frictional contact
25 of the surfaces.

European Patent application 91 309 615.2 discloses an erosion resistant coating for turbo machine gas path components which comprises the thermal spray depositing of a chromium carbide and an age hardenable nickel base alloy onto the surface of the gas path components and then preferably heat treating the gas path component. This reference is incorporated herein as if it were recited in its entirety.

30 The chromium carbide base thermal spray coating family has been in use for many years to provide sliding and impact wear resistance at elevated temperatures. The most frequently used system by far is the chromium carbide plus nickel chromium composite. The nickel chromium (usually Ni - 20 Cr) constituent of the coating has ranged from about 10 to about 35 weight percent. These coatings have been produced using all types of thermal spray processes including plasma spray deposition as well as detonation gun
35 deposition. The powder used for thermal spray deposition is usually a simple mechanical blend of the two components. While the chromium carbide component of the powder is usually Cr_3C_2 , the as-deposited coatings typically contain a preponderance of Cr_7C_3 along with lesser amounts of Cr_3C_2 and Cr_{23}C_6 . The difference between the powder composition and the as-deposited coating is due to the oxidation of the Cr_3C_2 with consequent loss of carbon. Oxidation may occur in detonation gun deposition as a result of oxygen or carbon dioxide in the detonation gases, while oxidation in plasma spraying occurs as a result of
40 inspiration of air into the plasma stream. Those coatings with a relatively high volume fraction of the metallic component have been used for self-mating wear resistance in gas turbine components at elevated temperatures. These coatings, because of the high metallic content, have good impact as well as fretting wear and oxidation resistance. At lower temperatures, coatings with nominally 20 weight percent nickel-
45 chromium have been used for wear against carbon and carbon graphite in mechanical seals, and for wear in general in adhesive and abrasive applications. These coatings are most frequently produced by thermal spraying. In this family of coating processes, the coating material, usually in the form of powder, is heated to near its melting point, accelerated to a high velocity, and impinged upon the surface to be coated. The particles strike the surface and flow laterally to form thin lenticular particles, frequently called splats, which
50 randomly interleaf and overlap to form the coating. The family of thermal spray coatings includes detonation gun deposition, oxy-fuel flame spraying, high velocity oxy-fuel deposition, and plasma spray.

It is an object of the present invention to provide a coating having excellent contact wear resistance for a contact surface of a face contact fluid seal.

55 It is another object of the present invention to provide a face contact fluid seal in which one of the contacting surfaces is coated with a chromium carbide-age hardenable nickel base alloy coating that has excellent contact wear characteristics.

It is another object of the present invention to provide a method for coating a contact surface of a face contact fluid seal with a chromium carbide-age hardenable nickel base alloy coating.

The foregoing and additional objects will become more apparent from the description and disclosure hereinafter set forth.

SUMMARY OF THE INVENTION

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The invention relates to a face contact fluid seal comprising a first member cooperating with and in contact with a second member with at least one of said members moving on the surface of the other member; the improvement wherein at least a portion of the surface of the one member in contact with the other member is coated with a chromium carbide-age hardenable nickel base alloy coating. The invention
10 also relates to a process for coating the contact surface of a face contact fluid seal with a chromium carbide-age hardenable nickel base alloy. Preferably the surface of the first member would be steel and the surface of the second member would be carbon.

Preferably, the as-deposited coated layer on the contact surface of the seal would be heated at an elevated temperature and for a time period sufficient to cause precipitation of intermetallic compounds within the nickel base alloy constituent of the coated layer. In the heat treatment step, there is a
15 transformation of the highly stressed microcrystalline as-deposited structure to a more ordered structure in which the phases exhibit well defined X-ray diffraction patterns.

As used herein, an age hardenable nickel base alloy shall mean a nickel base alloy that can be hardened by heating to cause a precipitation of an intermetallic compound from a supersaturated solution of the nickel base alloy. The intermetallic compound usually contains at least one element from the group consisting of aluminum, titanium, niobium and tantalum. Preferably the element should be present in an amount from 0.5 to 13 weight percent, more preferably from 1 to 9 weight percent of the coating. The preferred age hardenable nickel base alloy is Inconel 718 which contains about 53 weight percent nickel, about 19 weight percent iron, about 19 weight percent chromium, with the remainder being about 3 weight
25 percent molybdenum, about 5 weight percent niobium with about 1 weight percent tantalum and minor amounts of other elements. Inconel 718 when heated can be strengthened by nickel intermetallic compounds precipitating in an austenitic (fcc) matrix. Inconel 718 is believed to deposit a nickel-niobium compound as the hardening phase. For age hardening alloys precipitation starts at about 538 °C (1000 °F) and generally increases with increasing temperature. However, above a certain temperature, such as 899 °C (1650 °F), the secondary phase may go back into solution. The resolutioning temperature for Inconel 718 is 1550 °F (843 °C). Typical aging temperatures for Inconel 718 are from 1275 °F to 1400 °F (691 °C - 760 °C) with the generally preferred temperature being 1325 °F (718 °C). Generally for a nickel base alloy the age hardening temperature would be from 538 °C (1000 °F) to 899 °C (1650 °F) and preferably from 690 °C (1275 °F) to 760 °C (1400 °F). The time period of the heating treatment could generally be from at least 0.5
30 hour to 22 hours, preferably from 4 to 16 hours.

Suitable chromium carbides are Cr_3C_2 , Cr_{23}C_6 , Cr_7C_3 , with Cr_3C_2 being the preferred. Deposited coatings of Cr_3C_2 plus Inconel 718 have been examined by X-ray evaluation of the microstructure and found to consist predominantly or substantially of Cr_7C_3 plus Cr_{23}C_6 . It is believed that on long term exposure at elevated temperatures, the Cr_7C_3 may be converted to Cr_{23}C_6 . For most applications, the
40 chromium in the chromium carbide should be from 85 to 95 weight percent, and preferably about 87 weight percent.

For most applications, the weight percent of the chromium carbide component of the coating could vary from 50 to 95 weight percent, preferably from 70 to 90 weight percent and the age hardenable nickel base alloy could vary from 5 to 50 weight percent, preferably from 10 to 30 weight percent of the coating.

45 Flame plating by means of detonation using a detonating gun can be used to produce coatings of this invention. Basically, the detonation gun consists of a fluid-cooled barrel having a small inner diameter of about one inch. Generally a mixture of oxygen and acetylene is fed into the gun along with a coating powder. The oxygen-acetylene fuel gas mixture is ignited to produce a detonation wave which travels down the barrel of the gun whereupon the coating material is heated and propelled out of the gun onto an article to be coated. U.S. Patent 2,714,563 discloses a method and apparatus which utilizes detonation waves for
50 flame coating. The disclosure of this U.S. Patent 2,714,563 is incorporated herein by reference as if the disclosure was recited in full text in this specification.

In some applications it may be desirable to dilute the oxygen-acetylene fuel mixture with an inert gas such as nitrogen or argon. The gaseous diluent has been found to reduce the flame temperature since it
55 does not participate in the detonation reaction. U.S. Patent 2,972,550 discloses the process of diluting the oxygen-acetylene fuel mixture to enable the detonation-plating process to be used with an increased number of coating compositions and also for new and more widely useful applications based on the coating obtainable. The disclosure of this U.S. Patent 2,972,550 is incorporated herein by reference as if the

disclosure was recited in full text in this specification.

In other applications, a second combustible gas may be used along with acetylene, such gas preferably being propylene. The use of two combustible gases is disclosed in U.S. Patent 4,902,539 which is incorporated herein by reference as if the disclosure was recited in full text in this specification.

Plasma coating torches are another means for producing coatings of various compositions on suitable substrates according to this invention. The plasma coating technique is a line-of-sight process in which the coating powder is heated to near or above its melting point and accelerated by a plasma gas stream against a substrate to be coated. On impact the accelerated powder forms a coating consisting of many layers of overlapping thin lenticular particles or splats.

Another method of producing the coatings of this invention may be the high velocity oxy-fuel, including the so-called hypersonic flame spray coating processes. In these processes, oxygen and a fuel gas are continuously combusted thereby forming a high velocity gas stream into which powdered material of the coating composition is injected. The powder particles are heated to near their melting point, accelerated, and impinged upon the surface to be coated. Upon impact the powder particles flow outward forming overlapping thin, lenticular particles or splats.

The chromium carbide powders of the coating material for use in obtaining the coated layer of this invention are preferably powders made by the carbonization of chromium and then crushing the resultant product. In this process chromium and carbon are reaction sintered at a high temperature and the resultant sinter product is crushed and sized. The metallic powders are preferably produced by argon atomization followed by sizing. The powder components are then blended by mechanical mixing. The powder blend is normally used as the feed material in conventional thermal spray processes. However, agglomerated sintered powder can be used in which each agglomerated powder particle contains both the chrome carbide and metallic constituent.

Conventional type coatings of 20[80Ni20Cr] + 80 [Cr. Carbide] (hereinafter referred to as LCI) has been used on annular face seals mating against carbon for many years. These seals can operate at high surface speeds and relatively low unit loading, sealing oil from air at high operating temperatures. It is not unusual to find radial cracks in the contact zone of coated seals that have been operated at high temperatures. Such cracks are believed to be the result of local "hot spots" and can marginally increase the leakage rate across the seal but are generally tolerable. However, sometimes blisters can form in the contact zone, leading to an unacceptably high leakage rate. Analysis of these blistered seals suggested that radial cracking could be a precursor to blistering because it allows air penetration and oxidation of the substrate interface, weakening the coating bond in the vicinity of the crack.

It is believed that if the resistance to cracking caused by the "hot spots" can be improved, then the resistance to blistering and consequent leakage would be improved. A relatively inexpensive test was devised to model the stress sequence occurring at a localized contact spot on a seal. In the test the early compressive stress and elevated temperature of a "hot spot" is simulated by bending a coated bar with the coated side in compression and heating the bar while loaded. The cooling of the hot spot is then simulated by cooling the bar in the compressive state. After the bar is cooled it is unloaded and allowed to return to a flat condition. Depending on how much the coating yielded at the test load and temperature, the coating may crack before the bar returns to a flat condition. This can be considered comparable to the radial cracking which occurs during cooling of a "hot spot". Age hardened Inconel 718 was chosen as the substrate material for the test so that little to no yielding of the substrate itself would occur so that all changes would be due to coating characteristic changes.

The temperature experienced at a hot spot is not precisely known. Therefore preliminary experiments were done with LCI coatings at various compressive loads and temperatures. The compressive loads and temperatures were matched as follows. It was assumed that the seal runs at an average temperature of 148.9°C (300°F) and that the coating coefficient of thermal expansion (CTE) is $10.1 \times 10^{-6}/\text{deg C}$ ($5.6 \times 10^{-6}/\text{deg F}$). For a maximum assumed hot spot temperature, T, the associated maximum compressive strain was simplistically estimated as: $\text{CTE}(\text{coating}) \times (T - 300^\circ\text{F})$.

In the preliminary testing it was found that heating to 593.3°C (1100°F) with a corresponding compressive preload of 0.44% strain was sufficient to cause the LCI coating to crack just before it returned to a flat condition during the unloading portion of the test. Therefore that preload and temperature were standardized for the rest of the coatings tested.

Drawings

Figure 1 is a schematic of a four point bending test for bending a bar coated on the top with a layer of a chromium carbide-age hardenable nickel base alloy in which the bar is shown in the flat position.

Figure 2 is a schematic of the four point bending test of Figure 1 after a force has been applied to bend the bar.

Figure 3 is a schematic of a four point bending test for bending the bar of Figure 1 after the bar has been inverted and in which the bar is shown in the flat position.

Figure 4 is a schematic of the four point bending test of Figure 3 after a force has been applied to bend the bar.

Test Procedure

1. A 1/4 x 1/2 x 10 inch long Inconel 718 bar A was coated on one side at the center with a layer of chromium carbide-age hardenable nickel base alloy B for 2 1/4 inches as shown in Figure 1.
2. A type K chromel-alumel thermocouple C was welded to the edge side, 6.35 mm side, (1/4 inch side) of the bar as shown in Figure 1.
3. The bar was bent using a universal testing machine equipped with a four point bending fixture as schematically shown in Figure 1. The central load points are 69.9 mm (2.75 inches) apart, while the outer load points are 203.2 mm (8 inches) apart. Thus the coated area A was located in the constant strain region (uniform curvature) between the central load points.
4. The position of the load points was zeroed at the location where they just made contact with the flat bar A. Load was then applied to move the center points downward at a rate of 5.1 mm/minute (0.2 inch/minute) until they reached a point 0.230 inch from their starting point and the load was maintained as shown in Figure 2. This 5.84 mm (0.230 inch) displacement corresponds to a maximum surface strain across the center of the bar of 0.44% which was the standardized preload selected as discussed above. Displacement is related to maximum surface strain by the following relationship:

$$\epsilon = \frac{24 (d + t) \delta}{3l^2 - 4a^2}$$

- ϵ = maximum surface strain
- d = bar thickness
- t = coating thickness
- δ = displacement of the central load points from their starting position with the bar A flat
- l = distance between outer load points
- a = distance between inner load points

5. The coated bar with the applied load as shown in Figure 2 was placed into a furnace, preferably preheated to 648 °C (1200 °F). The bar temperature was continuously monitored using the thermocouple C. The coated bar was removed from the furnace when the bar reached 593 °C (1100 °F). This usually took about 15 to 30 minutes. With the load still applied, the coated bar was cooled to about 20 °C and then a piezo-electric transducer was coupled to the coating and attached to a recorder in order to detect possible cracking as the bar was unloaded. When and if the coating cracked, a sudden burst of energy was released which produced a stress wave which was detected by the transducer.
6. With the recorder on to monitor acoustic emission, the load was released at a controlled rate of 5.1 mm/minute (0.2 inch/minute) until the coated bar returned to a flat condition.
7. If no cracking is detected while unloading the bar, then the bar is turned over as shown in Figure 3. The bar is then bent as shown in Figure 4 placing the coating B in tension and the bending is continued to the point where acoustic emission indicates cracking.

EXAMPLE

Two sample coatings were applied to test bars as shown in the Table using a detonation gun process in which the combustion gas mixture contained acetylene and propylene.

In this test, chromium carbide-nickel chromium coating (Sample Coating A) was compared with a coating (Sample Coating B) of this invention, chromium carbide-Inconel 718, in both the as-coated and in the heat treated condition. Coatings about 250 micrometers thick were deposited on an Inconel 718 bar substrate using a detonation gun process. The starting coating powder for Coating B in the Table was 11% Inconel 718 and 89% chromium carbide. The starting powder for Coating A in the Table was 11 Ni20Cr and 89 chromium carbide.

As shown in the Table, heat treatment significantly improves the yield strength of the Cr carbide coatings and consequently should make them more resistant to thermal stress cracking on annular face seals. Coating B (coating of this invention) exhibits greater response to the heat treatment than did Coating A.

Table

Percent Tensile Strain to Produce Coating Cracking Following Compressive Loading at Elevated Temperature				
Coating Sample	Composition	As-Deposited	HT 538 °C (1000 °F)/20hr/vac	HT 718 °C (1325 °F)/8hr/vac
A	20[80Ni20Cr] + 80 [Cr. Carbide]	0*	0*	0.33%
B	20 [IN 718] + 80 [Cr. Carbide]	0*	0.27%	0.44%

* Coating cracked during removal of the compressive load and prior to application of any tensile load.

While the example above uses detonation gun means to apply the coatings, coatings of this invention may be produced using other thermal spray technologies, including, but not limited to, plasma spray, high velocity oxy-fuel deposition, and hypersonic flame spray.

As many possible embodiments may be made of this invention without departing from the scope thereof, it being understood that all matter set forth is to be interpreted as illustrative and not in a limiting sense.

Claims

1. A face contact fluid seal comprising a first member cooperating with and in contact with a second member with at least one of said members moving on the surface of the other member; characterised in that at least a portion of the surface of one member in contact with the other member is coated with a chromium carbide-age hardenable nickel base alloy coating.
2. The face contact fluid seal of claim 1 wherein said first member comprises metal or metal alloy coated with a chromium carbide-age hardenable nickel base alloy and said second member comprises a carbonaceous material.
3. The face contact fluid seal of claim 2 wherein said second member is carbon.
4. The face contact fluid seal of claim 1 wherein the age hardenable nickel base alloy coating is Inconel 718.
5. The face contact fluid seal of claim 1 wherein the age hardenable nickel base alloy contains about 53 weight percent nickel, about 19 weight percent chromium, about 19 weight percent iron, about 3 weight percent molybdenum, about 5 weight percent niobium and about 1 weight percent tantalum.
6. The face contact fluid seal of claim 1 wherein the chromium carbide is selected from the group consisting of Cr_3C_2 , Cr_7C_3 , $Cr_{23}C_6$ and mixtures thereof.
7. The face contact fluid seal of claim 6 wherein the chromium carbide is substantially Cr_7C_3 .
8. The face contact fluid seal of claim 1 wherein the chromium carbide comprises from 50 to 95 weight percent of the coating and the age hardenable nickel base alloy comprises from 5 to 50 weight percent of the coating.
9. The face contact fluid seal of claim 8 wherein the chrome carbide comprises from 70 to 90 weight percent and the age hardenable nickel base alloy is from 10 to 30 weight percent of this coating.

10. A process for coating a surface of a face contact seal with a coating component of chromium carbide and an age hardenable nickel base alloy, said face contact seal comprising a first member cooperating with and in contact with a second member and wherein said process comprises the steps of thermal spraying a powder composition of chromium carbide and an age hardenable nickel base alloy onto at least a portion of a surface of one of said members that is adopted to contact with said second member and then heating the as-deposited coating at a temperature sufficient to cause precipitation of intermetallic components within the nickel base alloy constituent of the coating.
11. The process of claim 10 wherein the as-deposited coating is heated at a temperature from 538 °C (1000 °F) to 899 °C (1650 °F) for a time period between 0.5 to 22 hours.
12. The process of claim 11 wherein the temperature is from 690 °C (1275 °F) to 760 °C (1400 °F) for a time period from 4 to 16 hours.
13. The process of claim 10 wherein the age hardenable nickel base alloy contains about 53 weight percent nickel, about 19 weight percent chromium, about 19 weight percent iron, about 3 weight percent molybdenum, about 5 weight percent niobium and about 1 weight percent tantalum.
14. The process of claim 10 wherein the chromium carbide is selected from the group consisting of Cr_3C_2 , Cr_7C_3 , Cr_{23}C_6 and mixtures thereof.
15. The process of claim 14 wherein the chromium carbide is Cr_3C_2 .
16. The process of claim 10 wherein the chromium carbide in the as-deposited coating comprises from 50 to 95 weight percent of the coating and the age hardenable nickel base alloy comprises from 5 to 50 weight percent of the coating.
17. The process of claim 16 wherein the chromium carbide in the as-deposited coating comprises from 70 to 90 weight percent and the age hardenable nickel base alloy is from 10 to 30 weight percent of this coating.
18. The process of claim 16 wherein said first member is a metal or metal alloy, said second member is a carbonaceous material and said coating is deposited on the surface of said first member.
19. The process of claim 18 wherein the first member is steel and the second member is carbon.

Patentansprüche

1. Stirnflächenkontakt-Fluiddichtung mit einem ersten Bauteil, das mit einem zweiten Bauteil zusammenwirkt und in Kontakt mit diesem steht, wobei sich mindestens eines der Bauteile auf der Oberfläche des anderen Bauteils bewegt, dadurch gekennzeichnet, daß mindestens ein Teil der Oberfläche des einen Bauteils, die mit dem anderen Bauteil in Kontakt steht, mit einem Überzug aus Chromkarbid und einer alterungshärtbaren Nickelbasislegierung beschichtet ist.
2. Stirnflächenkontakt-Fluiddichtung nach Anspruch 1, bei welcher das erste Bauteil ein Metall oder eine Metallegierung, das bzw. die mit einem Überzug aus Chromkarbid und einer alterungshärtbaren Nickelbasislegierung beschichtet ist, aufweist, und das zweite Bauteil einen kohlenstoffhaltigen Werkstoff aufweist.
3. Stirnflächenkontakt-Fluiddichtung nach Anspruch 2, bei welcher das zweite Bauteil aus Kohlenstoff besteht.
4. Stirnflächenkontakt-Fluiddichtung nach Anspruch 1, bei welcher der alterungshärtbare Nickelbasislegierungsüberzug aus Inconel 718 besteht.
5. Stirnflächenkontakt-Fluiddichtung nach Anspruch 1, bei welcher die alterungshärtbare Nickelbasislegierung etwa 53 Gew.% Nickel, etwa 19 Gew.% Chrom, etwa 19 Gew.% Eisen, etwa 3 Gew.% Molybdän, etwa 5 Gew.% Niob und etwa 1 Gew.% Tantal enthält.

6. Stirnflächenkontakt-Fluiddichtung nach Anspruch 1, bei welcher das Chromkarbid aus der aus Cr_3C_2 , Cr_7C_3 , Cr_{23}C_6 und Gemischen derselben bestehenden Gruppe ausgewählt ist.
7. Stirnflächenkontakt-Fluiddichtung nach Anspruch 6, bei welcher als Chromkarbid im wesentlichen Cr_7C_3 vorgesehen ist.
8. Stirnflächenkontakt-Fluiddichtung nach Anspruch 1, bei welcher das Chromkarbid 50 bis 95 Gew.% des Überzugs ausmacht und die alterungshärtbare Nickelbasislegierung 5 bis 50 Gew.% des Überzugs bildet.
9. Stirnflächenkontakt-Fluiddichtung nach Anspruch 8, bei welcher das Chromkarbid 70 bis 90 Gew.% und die alterungshärtbare Nickelbasislegierung 10 bis 30 Gew.% des Überzugs ausmachen.
10. Verfahren zum Beschichten einer Oberfläche einer Stirnflächenkontaktdichtung mit einer Überzugskomponente aus Chromkarbid und einer alterungshärtbaren Nickelbasislegierung, wobei die Stirnflächenkontaktdichtung ein erstes Bauteil aufweist, das mit einem zweiten Bauteil zusammenwirkt und in Kontakt mit diesem steht, und wobei das Verfahren die folgenden Verfahrensschritte aufweist: thermisches Spritzen einer Pulverzusammensetzung aus Chromkarbid und einer alterungshärtbaren Nickelbasislegierung auf mindestens einen Teil einer Oberfläche eines der Bauteile, die mit dem zweiten Bauteil in Kontakt kommen kann, und anschließendes Erhitzen des Überzugs im aufgetragenen Zustand bei einer Temperatur, die ausreicht, um ein Ausfällen von intermetallischen Komponenten innerhalb des Nickelbasislegierungsbestandteils des Überzuges zu bewirken.
11. Verfahren nach Anspruch 10, bei dem der Überzug im aufgetragenen Zustand bei einer Temperatur von 538°C (1000°F) bis 899°C (1650°F) für eine Zeitspanne von 0,5 bis 22 Stunden erhitzt wird.
12. Verfahren nach Anspruch 11, bei dem die Temperatur zwischen 690°C (1275°F) und 760°C (1400°F) liegt und die Zeitspanne 4 bis 16 Stunden beträgt.
13. Verfahren nach Anspruch 10, bei dem die alterungshärtbare Nickelbasislegierung etwa 53 Gew.% Nickel, etwa 19 Gew.% Chrom, etwa 19 Gew.% Eisen, etwa 3 Gew.% Molybdän, etwa 5 Gew.% Niob und etwa 1 Gew.% Tantal enthält.
14. Verfahren nach Anspruch 10, bei dem das Chromkarbid aus der aus Cr_3C_2 , Cr_7C_3 , Cr_{23}C_6 und Gemischen derselben bestehenden Gruppe ausgewählt wird.
15. Verfahren nach Anspruch 14, bei dem das Chromkarbid Cr_3C_2 ist.
16. Verfahren nach Anspruch 10, bei dem das Chromkarbid in dem Überzug im Auftragszustand 50 bis 95 Gew.% des Überzuges und die alterungshärtbare Nickelbasislegierung 5 bis 50 Gew.% des Überzuges ausmachen.
17. Verfahren nach Anspruch 16, bei dem das Chromkarbid in dem Überzug im aufgetragenen Zustand 70 bis 90 Gew.% ausmacht und die alterungshärtbare Nickelbasislegierung 10 bis 30 Gew.% dieses Überzuges ausmacht.
18. Verfahren nach Anspruch 16, bei dem das erste Bauteil aus einem Metall oder einer Metallegierung besteht, das zweite Bauteil aus einem kohlenstoffhaltigen Werkstoff besteht und der Überzug auf die Oberfläche des ersten Bauteils aufgebracht wird.
19. Verfahren nach Anspruch 18, bei dem das erste Bauteil aus Stahl besteht und das zweite Bauteil aus Kohlenstoff besteht.

Revendications

1. Joint d'étanchéité aux fluides à contact face contre face comportant un premier élément coopérant avec un second élément avec lequel il est en contact, au moins l'un desdits éléments se déplaçant sur la surface de l'autre élément ; caractérisé en ce qu'au moins une partie de la surface d'un élément en

contact avec l'autre élément est revêtu d'un revêtement de carbure de chrome et d'un alliage à base de nickel durcissable par vieillissement.

2. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 1, dans lequel ledit premier élément comprend un métal ou un alliage métallique revêtu de carbure de chrome et d'un alliage à base de nickel durcissable par vieillissement, et ledit second élément comprend une matière carbonée.
3. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 2, dans lequel ledit second élément est en carbone.
4. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 1, dans lequel le revêtement d'alliage à base de nickel durcissable par vieillissement est en Inconel 718.
5. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 1, dans lequel l'alliage à base de nickel durcissable par vieillissement contient environ 53 pour cent en poids de nickel, environ 19 pour cent en poids de chrome, environ 19 pour cent en poids de fer, environ 3 % en poids de molybdène, environ 5 pour cent en poids de niobium et environ 1 pour cent poids de tantale.
6. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 1, dans lequel le carbure de chrome est choisi dans le groupe constitué de Cr_3C_2 , Cr_7C_3 , Cr_{23}C_6 et de mélanges de ceux-ci.
7. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 6, dans lequel le carbure de chrome est sensiblement du Cr_7C_3 .
8. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 1, dans lequel le carbure de chrome constitue 50 à 95 pour cent en poids du revêtement et l'alliage à base de nickel durcissable par vieillissement constitue 5 à 50 pour cent en poids du revêtement.
9. Joint d'étanchéité aux fluides à contact face contre face selon la revendication 8, dans lequel le carbure de chrome constitue 70 à 90 pour cent en poids et l'alliage à base de nickel durcissable par vieillissement constitue 10 à 30 pour cent en poids de ce revêtement.
10. Procédé pour revêtir une surface d'un joint d'étanchéité à contact face contre face, avec une pièce de revêtement en carbure de chrome et un alliage à base de nickel durcissable par vieillissement, ledit joint d'étanchéité à contact face contre face comportant un premier élément coopérant avec un second élément avec lequel il est en contact, et dans lequel ledit procédé comprend les étapes de projection à chaud d'une composition en poudre de carbure de chrome et d'un alliage à base de nickel durcissable par vieillissement, sur au moins une partie d'une surface de l'un desdits éléments qui est destinée à être en contact avec ledit second élément, puis le chauffage du revêtement tel que déposé à une température suffisante pour provoquer une précipitation de constituants intermétalliques à l'intérieur du constituant en alliage à base de nickel du revêtement.
11. Procédé selon la revendication 10, dans lequel le revêtement tel que déposé est chauffé à une température de 538°C (1000°F) à 899°C (1650°F) pendant une période comprise entre 0,5 et 22 heures.
12. Procédé selon la revendication 11, dans lequel la température est de 690°C (1275°F) à 760°C (1400°F) pendant une période de 4 à 16 heures.
13. Procédé selon la revendication 10, dans lequel l'alliage à base de nickel durcissable par vieillissement contient environ 53 pour cent en poids de nickel, environ 19 pour cent en poids de chrome, environ 19 pour cent en poids de fer, environ 3 pour cent en poids de molybdène, environ 5 pour cent en poids de niobium et environ 1 pour cent en poids de tantale.
14. Procédé selon la revendication 10, dans lequel le carbure de chrome est choisi dans le groupe constitué de Cr_3C_2 , Cr_7C_3 , Cr_{23}C_6 et de mélanges de ceux-ci.

15. Procédé selon la revendication 14, dans lequel le carbure de chrome est du Cr_3C_2 .

5 16. Procédé selon la revendication 10, dans lequel le carbure de chrome dans le revêtement tel que déposé constitue 50 à 95 pour cent en poids du revêtement et l'alliage à base de nickel durcissable par vieillissement constitue 5 à 50 pour cent en poids du revêtement.

10 17. Procédé selon la revendication 16, dans lequel le carbure de chrome dans le revêtement tel que déposé constitue 70 à 90 pour cent en poids et l'alliage à base de nickel durcissable par vieillissement constitue 10 à 30 pour cent en poids de ce revêtement.

18. Procédé selon la revendication 16, dans lequel ledit premier élément est un métal ou un alliage métallique, ledit second élément est une matière carbonée et ledit revêtement est déposé sur la surface dudit premier élément.

15 19. Procédé selon la revendication 18, dans lequel le premier élément est de l'acier et le second élément est du carbone.

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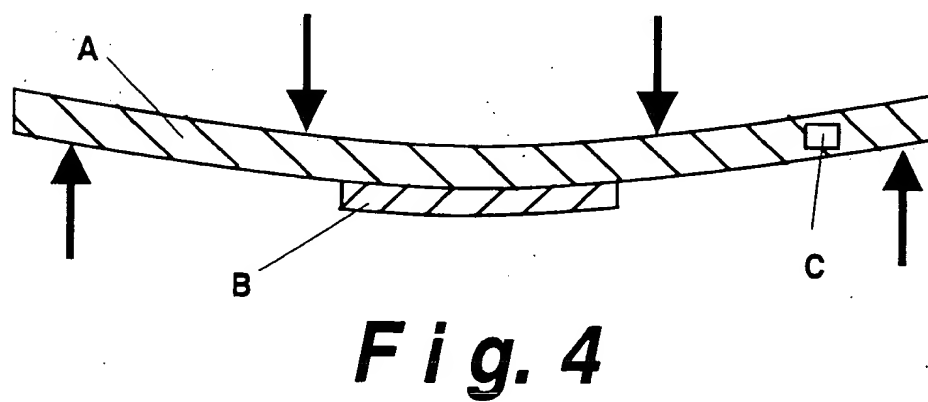
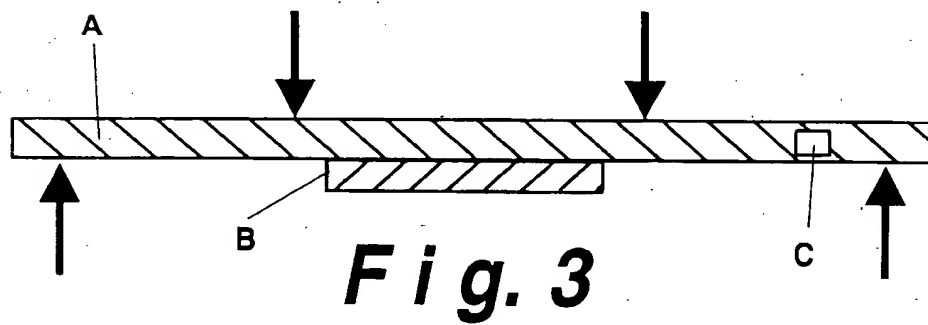
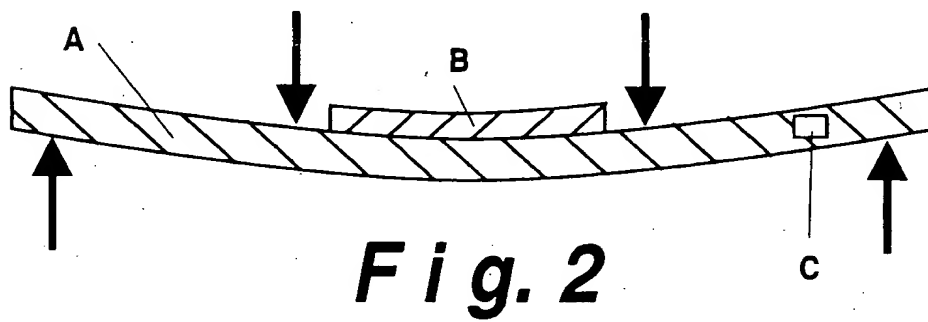
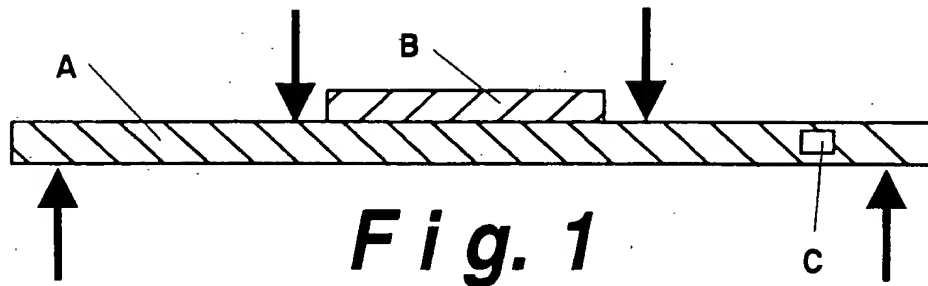
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